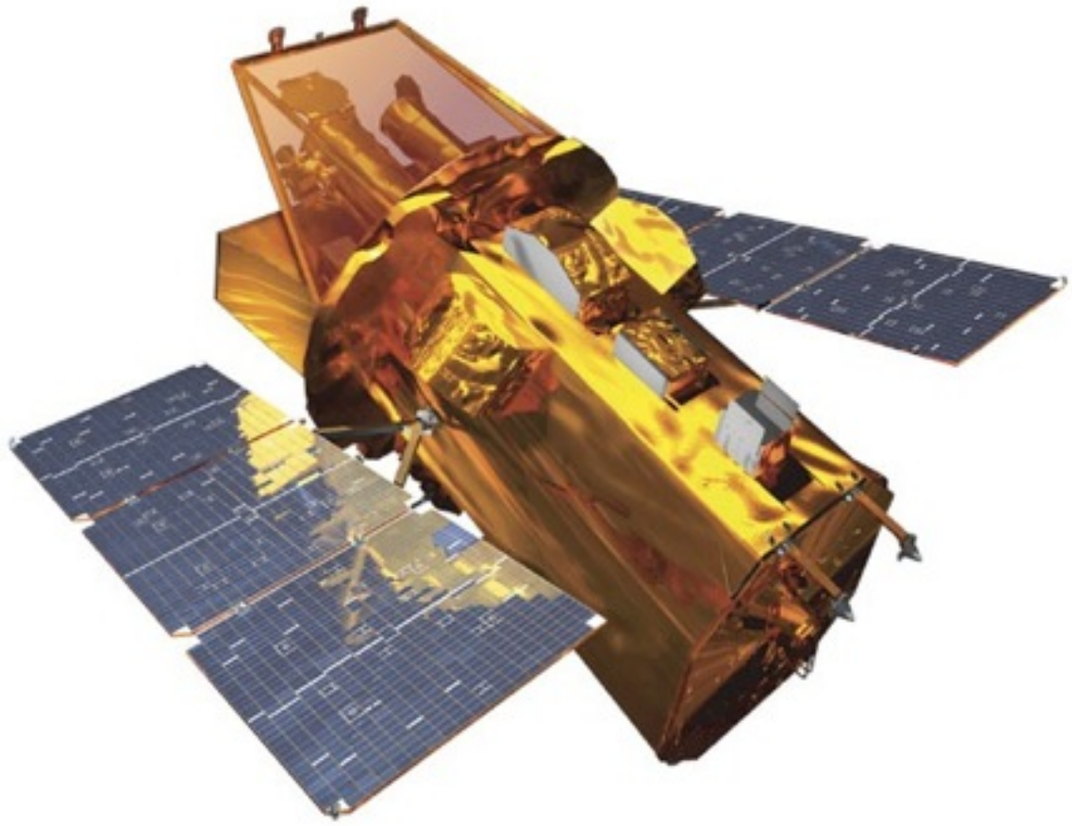
SWIFT BOOT CAMP

iPTF Summer School - 27 August 2015



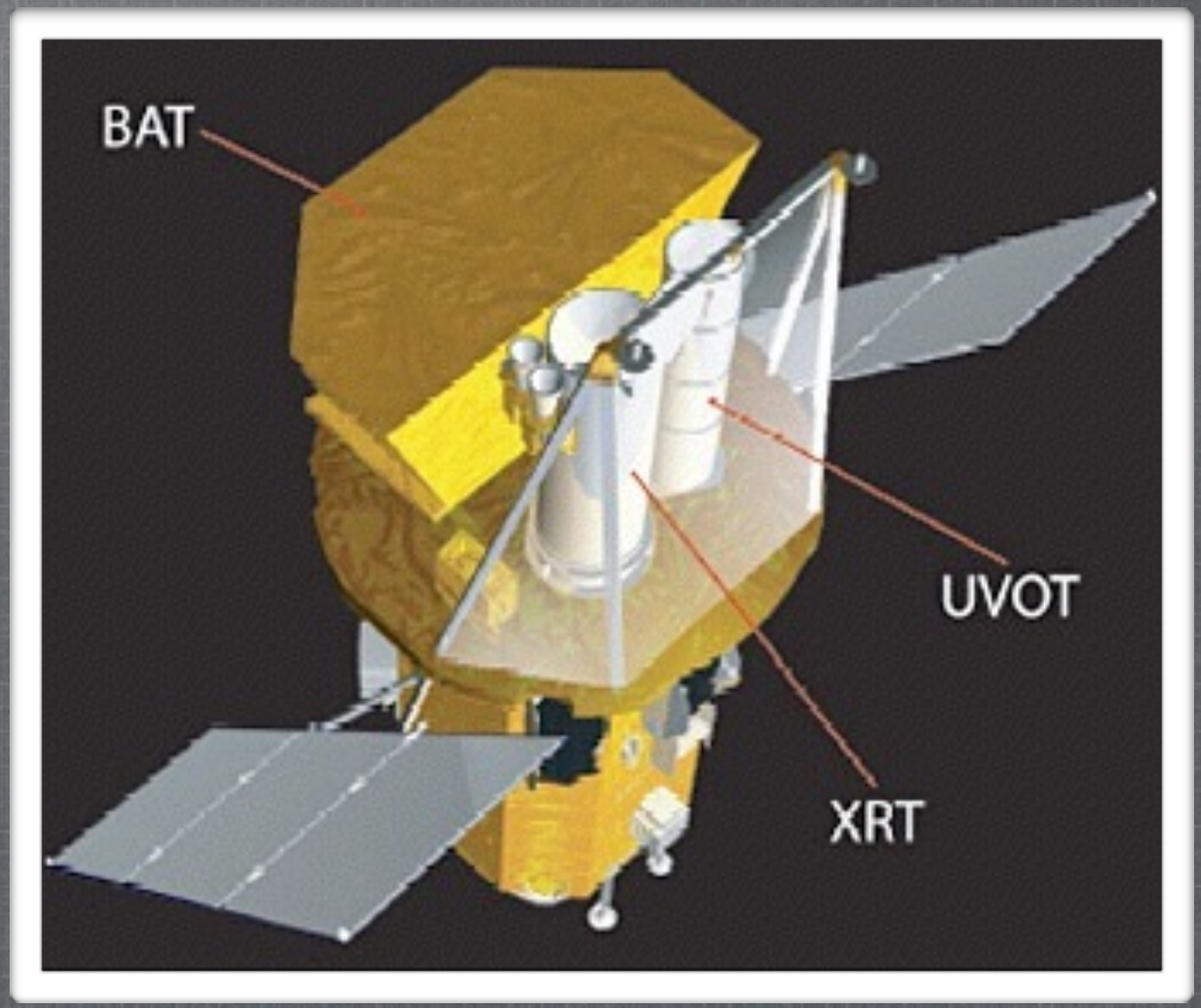
http://asd.gsfc.nasa.gov/Brad.Cenko/BootCamp/Swift.html

INSTRUMENT SUITE

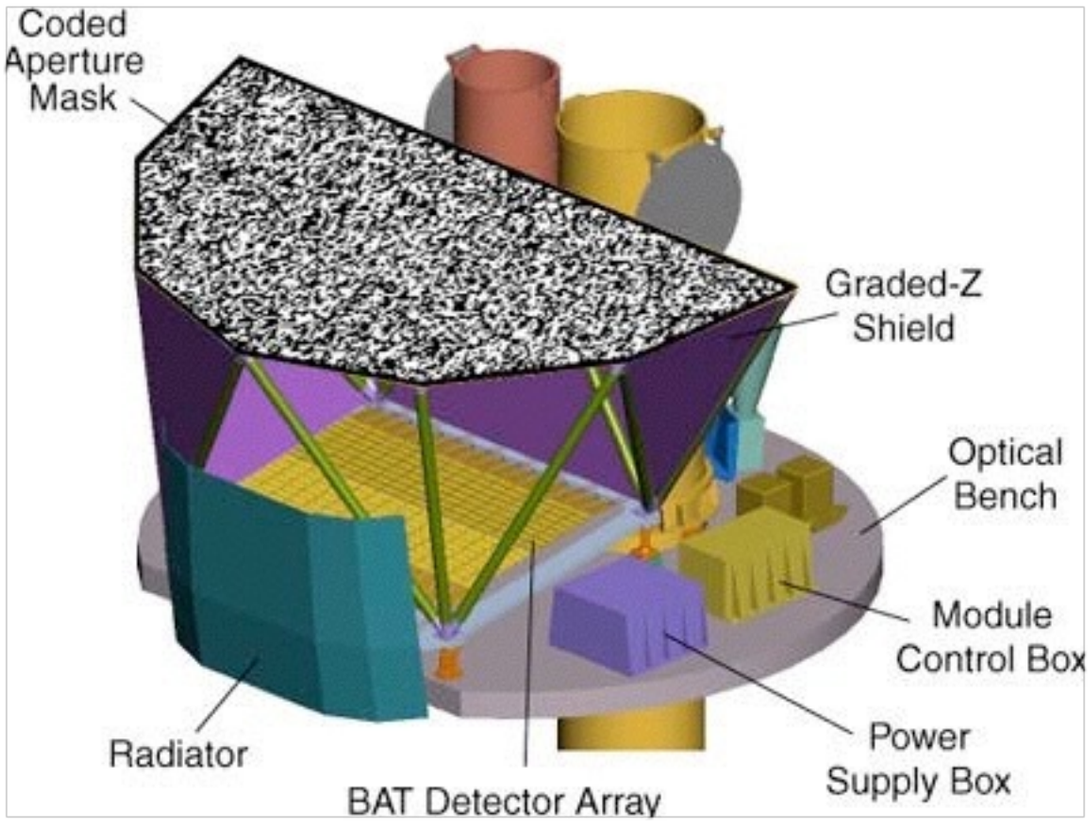
- Burst Alert Telescope (BAT): 15-350 keV, 1.4 sr field-of-view, ~ 3′ resolution

- X-ray Telescope (XRT): 0.2-10 keV, 24′ x 24′ field-of-view, ~ 3″ resolution

- Ultra-Violet Optical Telescope (UVOT): 170-650 nm, 17′ x 17′ field-of-view, ~ 0.5″ resolution

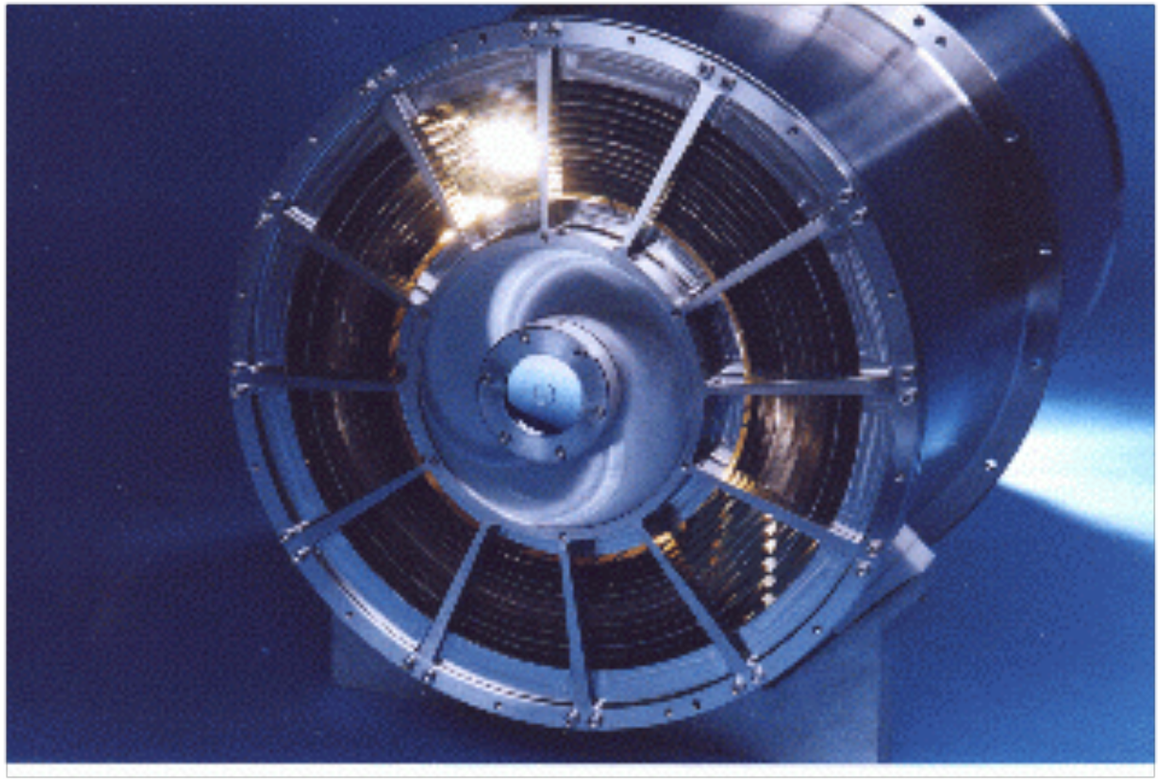


BAT "OPTICS"



D-shaped coded-aperture mask with ~ 54,000 5x5x1 mm Pb tiles in pseudo-random pattern (< 150 keV)

XRT OVERVIEW



Optics spare from JET-X mission (planned for initial launch of Spectrum X-Gamma (e.g., *eROSITA*)). Detectors spare from *XMM-Newton* (EPIC).

TABLE I

XRT instrument characteristics.

Telescope	Wolter I (3.5 m focal length)
Detector	e2v CCD-22
Detector format	600 × 600 pixels
Pixel size	40 μm × 40 μm
Readout modes	Image (IM) mode
	Photodiode (PD) mode
	Windowed timing (WT) mode
	Photon-counting (PC) mode
Pixel scale	2.36 arcseconds/pixel
Field of view	23.6 × 23.6 arcminutes
PSF	18 arcseconds HPD @ 1.5 keV
	22 arcseconds HPD @ 8.1 keV
Position accuracy	3 arcseconds
Time resolution	0.14 ms, 1.8 ms, or 2.5 s
Energy range	0.2–10 keV
Energy resolution	140 eV @ 5.9 keV (at launch)
Effective area	~125 cm^2 @ 1.5 keV
	~20 cm^2 @ 8.1 keV
Sensitivity	2×10^{-14} erg cm^{-2} s^{-1} in 10^4 s
Operation	Autonomous

Burrows et al., SSR, 2005

XRT READOUT MODES

Figure 2.1: Sequence of the XRT mode for an Automatic Target

Mode	Image capability	Spectral Capability	Time resolution	Cal sources in FOV	On-board Event reconstruction	Flux level mode switch
PU & LR	no	Yes	0.14 ms	yes	no, done on-ground	0.6-60 Crab
WT	1D	Yes	1.7 ms	no	no, done on ground	1-600 mCrab
PC	2D	Yes	2.5 s	See window size	yes	< 1 mCrab
IM	2D	No	0.1 s (short)	yes	not applicable	> 140 mCrab
		No	2.5 s (long)			< 5.6 mCrab

- Photon Counting (PC): Full 2D image, but "pile-up" at >~ 1 ct s^{-1}
- Window timing (WT): 1D image, less pile-up for bright sources
- Auto: Switch between WT and PC based on count rate

UVOT OVERVIEW

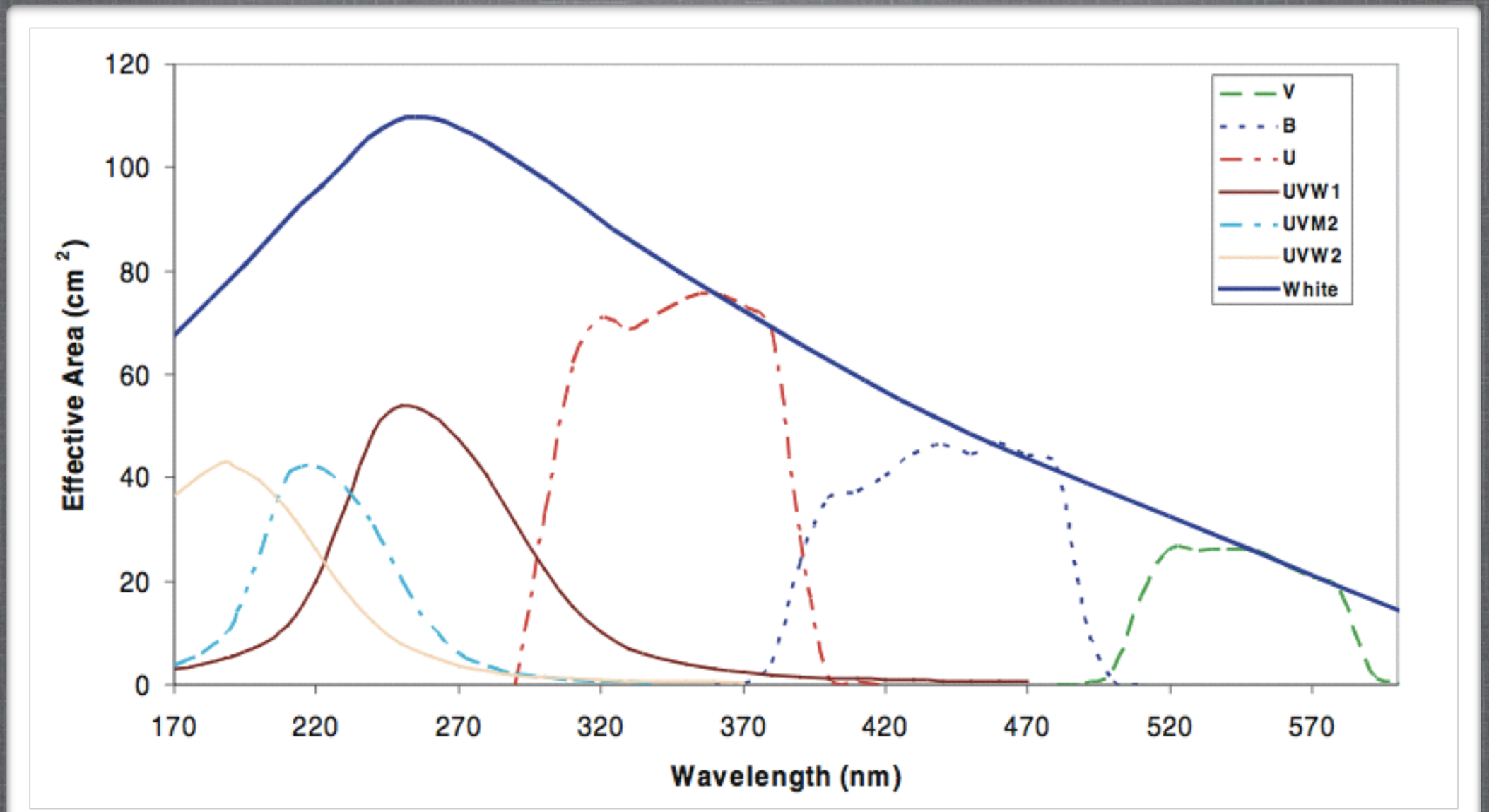
TABLE I

UVOT Characteristics.

Telescope	Modified Ritchey-Chrétien
Aperture	30 cm diameter
f-Number	12.7
Filters	11
Wavelength range	170–600 nm
Detector	MCP Intensified CCD
Detector operation	Photon counting
Sensitivity	$m_B = 24.0$ in white light in 1000s
Field of view	17×17 (arcmin^2)
Detection element	256×256 (pixels)
Sampling element	2048×2048 after centroiding
Telescope PSF	0.9 arcsec FWHM @ 350 nm
Pixel scale	0.5 arcsec

Roming et al., SSR, 2005

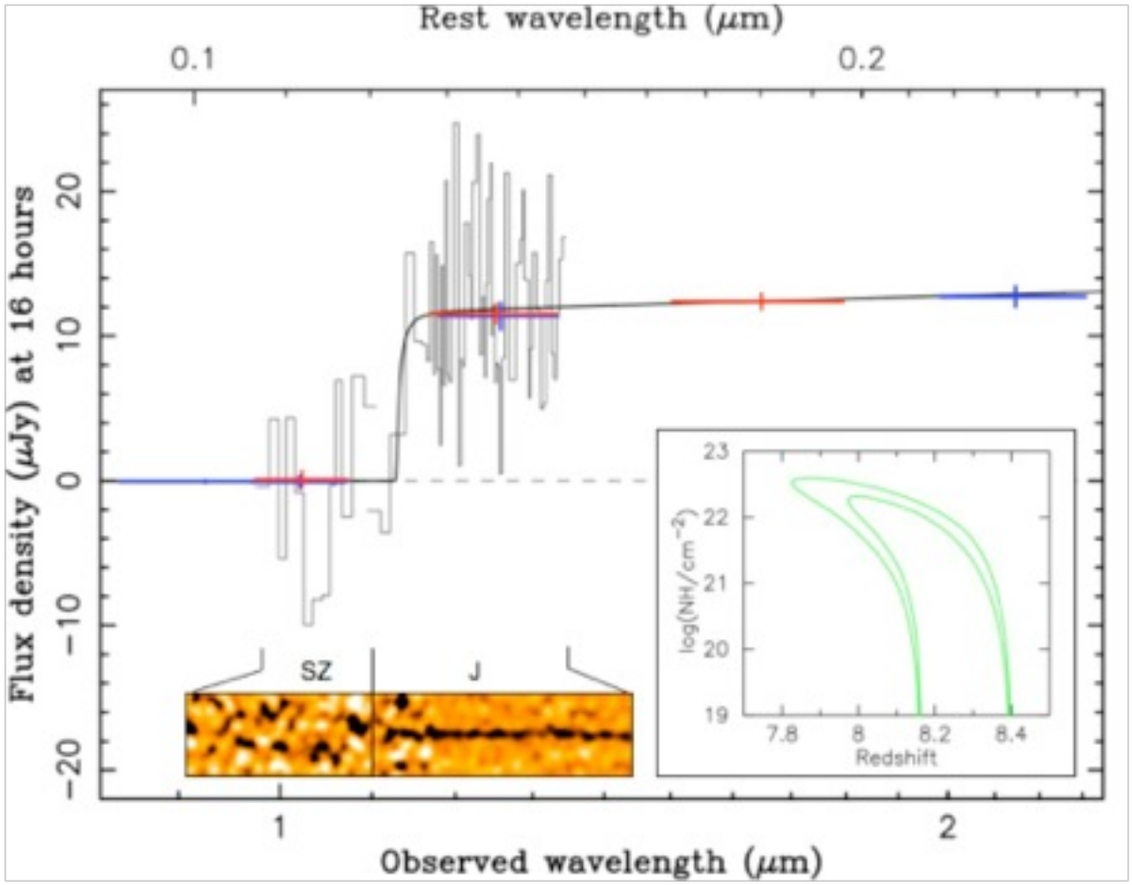
UVOT FILTERS



Roming et al., SSR, 2005

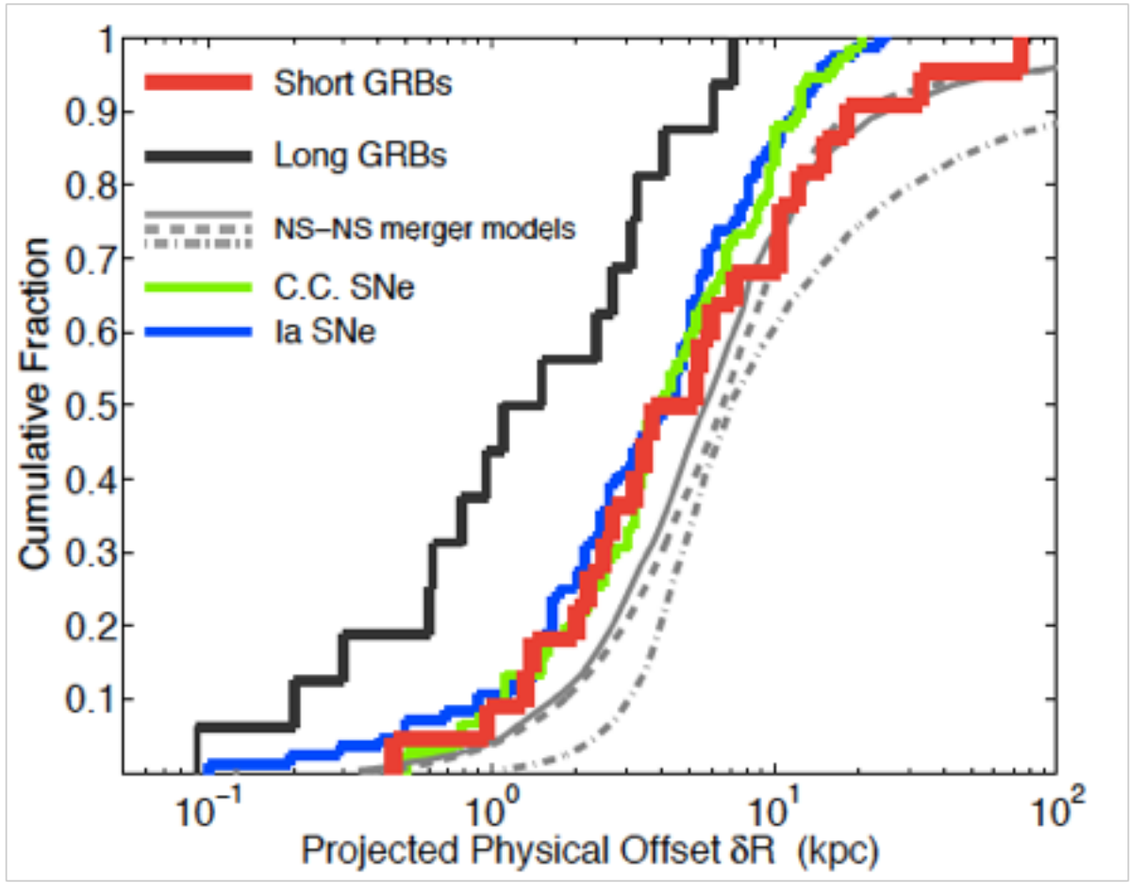
PRIMARY SCIENCE DRIVER: GRBs

GRB090423 @ $z \sim 8.2$



Tanvir *et al.*, 2009

First short-hard afterglows and hosts

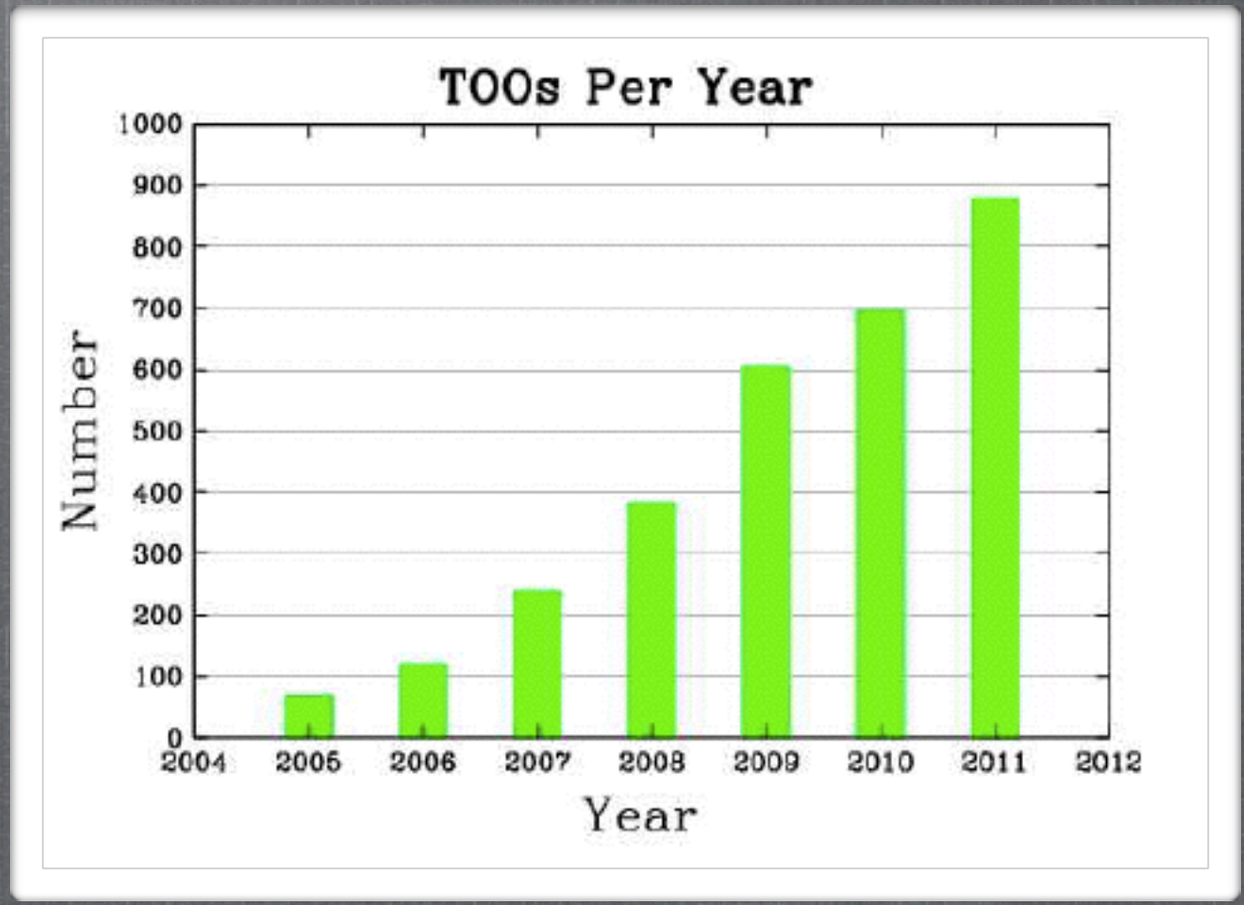


Fong *et al.*, 2013

Discovery (BAT) and rapid follow-up (XRT, UVOT) of gamma-ray bursts and their afterglows

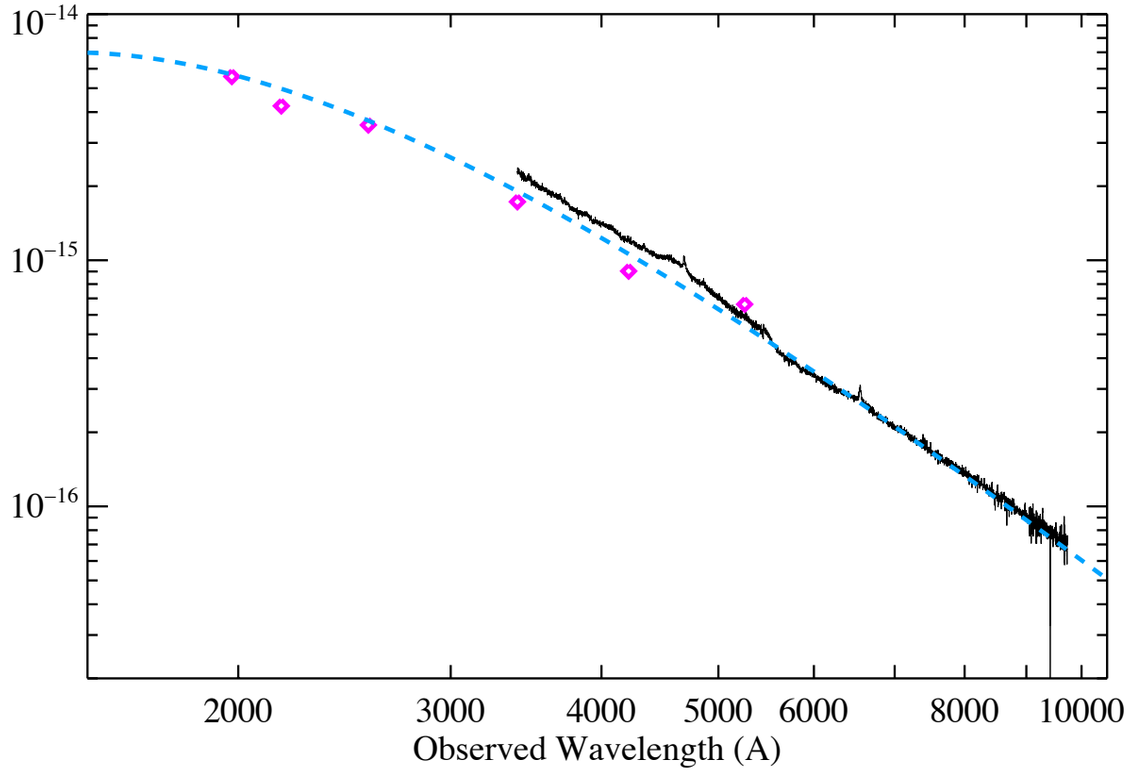
"SECONDARY" SCIENCE: TIME-DOMAIN FACILITY

- Supernovae, X-ray binaries, novae, AGN, ULXs, etc. originally considered ancillary, now dominate observing time
- Observatory receives average ~ 3 ToO requests per day (very high acceptance rate)
- All data promptly available (hours of taken) and *public*

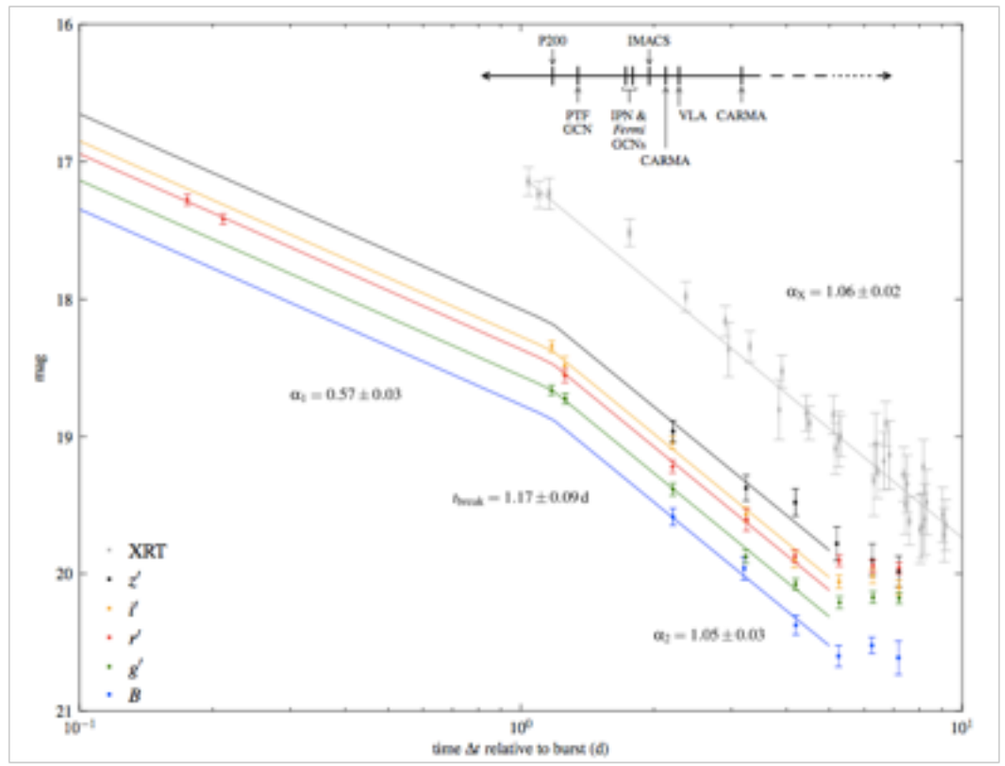


IPTF+*SWIFT*

PTF10gva: T ≈ 22000 K



iPTF13bxl / GRB130702A



Singer *et al.*, 2013

Swift follow-up to-date generally focused on young SN (shock breakout, CSM density) and exotic transients

SWIFT GI PROGRAM

- *Swift* Cycle 12: Estimated $1.2M awarded, typical grant size $40k
- Target-of-Opportunity observations (on all time scales) as well as non-time critical targets
- *All data immediately public, regardless if awarded through GI program*
- Due September 25, 2015

SWIFT ToO WEBPAGE

https://www.swift.psu.edu/too.html

SWIFT ToO WEBPAGE

- Only trigger "highest" priority observations in truly exceptional circumstances (high will usually suffice)
- *Swift* daily planning meetings happen at 09:00 Eastern time (schedule confirmed for next day)
- Typical requests (per observation) are ~ few ks (up to 10 ks rarely)
- UVOT filter code "0x223f": 6 filters, weighted to UV bands (V:B:U:W1:M2:W2 = 1:1:1:3:8:5)

DAILY PLAN (PPST/AFST)

PPST for August 7th, 2013 (DoY 219)

August 7th 2013

PPST AFST

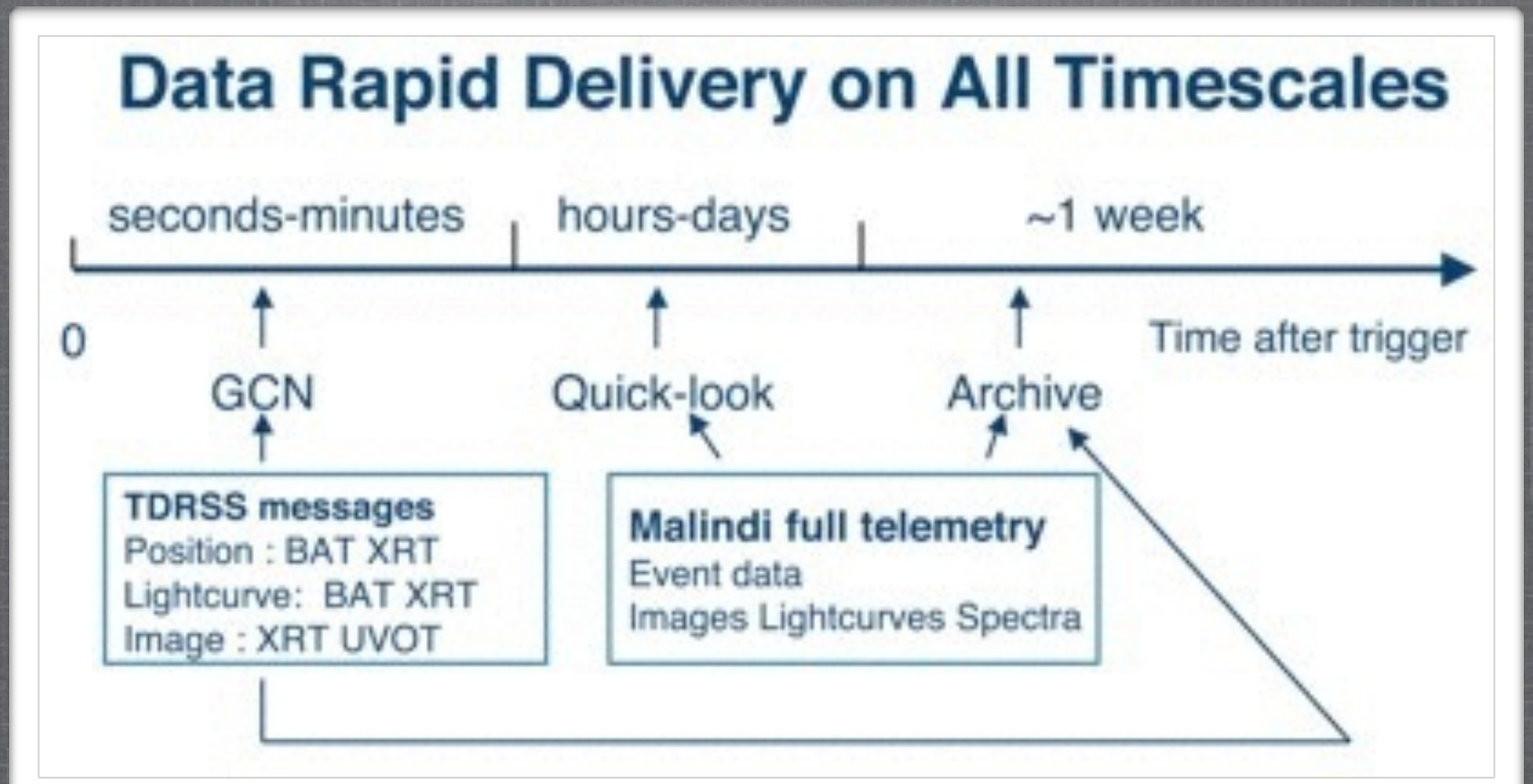
View

Notes:
Click on target ID to see a summary for all segments belonging to that target ID.
Click on segment number to see information for just that segment.
PPST time is calculated from begin to end. This does not take slewing into account.
SAA Cold - Observation performed during passage through the South-Atlantic Anomoly (SAA) to aide XRT passive cooling. No data is collected during SAA passages.

Begin	End	Target ID	Seg.	Target Name	R.A.	Dec.	Roll	XRT Mode	UVOT Mode	FoM	Time (s)
2013-08-07 00:00:00	2013-08-07 00:05:00	82072	3	RMJ131823.6-003146.3	199.57524	-0.53955	293.65107	PC	0x018c	51	300
2013-08-07 00:05:00	2013-08-07 00:10:00	82078	2	RMJ151511.1+035054.6	228.77272	3.84021	289.39046	PC	0x018c	51	300
2013-08-07 00:10:00	2013-08-07 00:15:00	91711	102	NGC 5548	214.49800	25.13680	284.00000	PC	0x018c	88	300
2013-08-07 00:15:00	2013-08-07 00:45:00	91711	103	NGC 5548	214.49800	25.13680	284.00000	PC	0x122f	88	1800
2013-08-07 00:45:00	2013-08-07 01:15:00	32619	19	XMMU J001528.9-391319	3.89356	-39.21251	112.23961	PC	0x018c	80	1800
2013-08-07 01:15:00	2013-08-07 01:40:00	31442	77	NGC 1313 X-2	49.61656	-66.60293	84.56670	PC	0x018c	74	1500
2013-08-07 01:40:00	2013-08-07 01:45:00	82072	3	RMJ131823.6-003146.3	199.57562	-0.54037	295.71195	PC	0x018c	51	300
2013-08-07 01:45:00	2013-08-07 01:50:00	49352	9	2FGL J1624.1-4040	246.01597	-40.66965	261.71677	PC	0x018c	60	300
2013-08-07 01:50:00	2013-08-07 02:01:00	32822	18	SN2013cj	256.19853	12.90747	298.91439	PC	0x308f	72	660
2013-08-07 02:01:00	2013-08-07 02:31:00	32894	4	4C+38.41	248.79065	38.12735	286.82229	PC	0x30ed	88	1800
2013-08-07 02:31:00	2013-08-07 02:56:00	35336	114	M31_1	10.70188	41.25139	43.77909	PC	0x018c	74	1500
2013-08-07 02:56:00	2013-08-07 03:09:00	49707	4	MASER 055542.63+0323	88.94951	3.38009	61.10861	PC	0x018c	40	780
2013-08-07 03:09:00	2013-08-07 03:15:00	82072	3	RMJ131823.6-003146.3	199.57517	-0.53940	293.26494	PC	0x018c	51	360
2013-08-07 03:15:00	2013-08-07 03:21:00	82074	2	RMJ135015.5+291317.3	207.54032	29.21617	282.28370	PC	0x018c	51	360
2013-08-07 03:21:00	2013-08-07 03:51:00	32876	38	PTF13bxl	217.28750	15.76728	285.58553	PC	0x018c	82	1800
2013-08-07 03:51:00	2013-08-07 04:07:00	32894	4	4C+38.41	248.79150	38.12498	292.59857	PC	0x30ed	88	960
2013-08-07 04:07:00	2013-08-07 04:33:00	35336	114	M31_1	10.70349	41.25308	49.12857	PC	0x018c	74	1560

http://www.swift.psu.edu/operations/obsSchedule.php

RETRIEVING DATA



Archive: http://heasarc.gsfc.nasa.gov/cgi-bin/W3Browse/swift.pl
Quick-look: http://swift.gsfc.nasa.gov/cgi-bin/sdc/ql?

QUICKLOOK PAGE

iPTF13bjx - Sequence: 00032850003 Version: 006

Target ID Sequence ID

You have the following download options:

- (•) Automatically unpack the data using a Java applet
- ( ) Download a tar file.

Select files below, then click this button to download the data:

Download

- [ ] **All Files**
  - [ ] **auxil**

sw00032850003pat.fits	FITS	56 kB	(level 3) Corrected attitude file
sw00032850003pjb.par	ASCII	3 kB	(level 1) Job parameter file
sw00032850003pob.cat	FITS	4 kB	(level 1) FITS format tape contents
sw00032850003ppr.par	ASCII	6 kB	(level 1) Processing parameter file
sw00032850003s.mkf	FITS	155 kB	(level 2) Makefilter filter file
sw00032850003sao.fits	FITS	3868 kB	(level 1) Attitude/orbit-related filter values
sw00032850003sat.fits	FITS	59 kB	(level 1) Spacecraft attitude file
sw00032850003sen.hk	FITS	336 kB	(level 1) S/C engineering data
sw00032850003sti.fits	FITS	4 kB	(level 1) UTC corrections file
sw00032850003uat.fits	FITS	43 kB	(level 3) Corrected attitude file
SWIFT_TLE_ARCHIVE.txt.13162.48183213	ASCII	84 kB	(level 1) TLE orbit file

  - [ ] **bat**
    - [ ] **event**
      - sw00032850003bevshsl_uf.evt FITS 19534 kB (level 1) Calibrated unscreened event file

QUICKLOOK UVOT

- **uvot**
  - **hk**
    - sw00032850003uac.hk FITS 8 kB (level 1) Housekeeping data
    - sw00032850003uaf.hk FITS 33 kB (level 1) Housekeeping data
    - sw00032850003uct.hk FITS 10 kB (level 1) Housekeeping data
    - sw00032850003uen.hk FITS 93 kB (level 1) instrument engineering data
    - sw00032850003uer.hk FITS 5 kB (level 1) Housekeeping data
    - sw00032850003ues.hk FITS 5 kB (level 1) Housekeeping data
  - **image**
    - sw00032850003ubb_ex.img FITS 125 kB (level 2) Uvot filter exp images
    - sw00032850003ubb_rw.img FITS 1451 kB (level 1) Raw coordinate images
    - sw00032850003ubb_sk.img FITS 5083 kB (level 2) Uvot filter sky images
    - sw00032850003um2_ex.img FITS 133 kB (level 2) Uvot filter exp images
    - sw00032850003um2_rw.img FITS 412 kB (level 1) Raw coordinate images
    - sw00032850003um2_sk.img FITS 2175 kB (level 2) Uvot filter sky images
    - sw00032850003uuu_ex.img FITS 126 kB (level 2) Uvot filter exp images
    - sw00032850003uuu_rw.img FITS 998 kB (level 1) Raw coordinate images
    - sw00032850003uuu_sk.img FITS 4339 kB (level 2) Uvot filter sky images
    - sw00032850003uvv_ex.img FITS 125 kB (level 2) Uvot filter exp images
    - sw00032850003uvv_rw.img FITS 1188 kB (level 1) Raw coordinate images
    - sw00032850003uvv_sk.img FITS 4706 kB (level 2) Uvot filter sky images
    - sw00032850003uw1_ex.img FITS 275 kB (level 2) Uvot filter exp images
    - sw00032850003uw1_rw.img FITS 578 kB (level 1) Raw coordinate images
    - sw00032850003uw1_sk.img FITS 3120 kB (level 2) Uvot filter sky images
    - sw00032850003uw2_ex.img FITS 127 kB (level 2) Uvot filter exp images
    - sw00032850003uw2_rw.img FITS 607 kB (level 1) Raw coordinate images
    - sw00032850003uw2_sk.img FITS 3302 kB (level 2) Uvot filter sky images
  - **products**
    - sw00032850003u.cat FITS 121 kB (level 3) Uvot source list
    - sw00032850003u_ex.img FITS 3658 kB (level 2) Exposure map images
    - sw00032850003u_sk.img FITS 24745 kB (level 2) Sky coordinate images
    - sw00032850003ubbskim.gif GIF 106 kB (level 3) Ximage plot of sky coord image
    - sw00032850003um2skim.gif GIF 125 kB (level 3) Ximage plot of sky coord image
    - sw00032850003uuuskim.gif GIF 116 kB (level 3) Ximage plot of sky coord image
    - sw00032850003uvvskim.gif GIF 111 kB (level 3) Ximage plot of sky coord image
    - sw00032850003uw1skim.gif GIF 117 kB (level 3) Ximage plot of sky coord image
    - sw00032850003uw2skim.gif GIF 118 kB (level 3) Ximage plot of sky coord image

Housekeeping data. Safely ignored.

sw00032850003ubb_ex.img

bb, m2, etc. = Filter code
ex = Exposure map
sk = Sky image (WCS)
rw = Raw image (no WCS)

Grab all sky images (exposure maps if you will be coadding different sequences)

High-level products optional
(I never use them)

QUICKLOOK XRT

- **xrt**
  - **event**
    - sw00032850003xpcw3po_cl.evt FITS 26 kB (level 2) Screened event file
    - sw00032850003xpcw3po_uf.evt FITS 865 kB (level 1) Calibrated unscreened event file
    - sw00032850003xwtw2sl_cl.evt FITS 10 kB (level 2) Screened event file
    - sw00032850003xwtw2sl_uf.evt FITS 26 kB (level 1) Calibrated unscreened event file
    - sw00032850003xwtw2sl_ufre.evt FITS 14 kB (level 1a) Reconstructed events (XRT)
    - sw00032850003xwtw2st_cl.evt FITS 10 kB (level 2) Screened event file
    - sw00032850003xwtw2st_uf.evt FITS 17 kB (level 1) Calibrated unscreened event file
    - sw00032850003xwtw2st_ufre.evt FITS 11 kB (level 1a) Reconstructed events (XRT)
  - **hk**
    - sw00032850003xbf_rw.img FITS 201 kB (trend) XRT bias image mode data
    - sw00032850003xen.hk FITS 78 kB (level 1) instrument engineering data
    - sw00032850003xhd.hk FITS 137 kB (level 1) Housekeeping data
    - sw00032850003xtr.hk FITS 11 kB (level 1) Housekeeping data
  - **products**
    - sw00032850003x_skim.gif GIF 9 kB (level 3) Ximage plot of sky coord image
    - sw00032850003xpc_ex.img FITS 156 kB (level 2) Exposure map images
    - sw00032850003xpc_sk.img FITS 16 kB (level 2) Sky coordinate images

sw00032850003xpcw3po_cl.evt - “pc” = operating mode, “w3” = window code, “po” = pointed observation, “cl” = level 2 (cleaned) event file

Download all Level 2 event files

DOWNLOADED DATA

2. tcsh

```
[gs66-iniesta:~/TALKS/iPTF2013] scenko% tar -xvf ~/Downloads/sw00032850003.006.tar
x 00032850003/uvot/image/sw00032850003ubb_sk.img.gz
x 00032850003/uvot/image/sw00032850003um2_sk.img.gz
x 00032850003/uvot/image/sw00032850003uuu_sk.img.gz
x 00032850003/uvot/image/sw00032850003uvv_sk.img.gz
x 00032850003/uvot/image/sw00032850003uw1_sk.img.gz
x 00032850003/uvot/image/sw00032850003uw2_sk.img.gz
x 00032850003/xrt/event/sw00032850003xpcw3po_cl.evt.gz
x 00032850003/xrt/event/sw00032850003xwtw2sl_cl.evt.gz
x 00032850003/xrt/event/sw00032850003xwtw2st_cl.evt.gz
[gs66-iniesta:~/TALKS/iPTF2013] scenko% gunzip 00032850003/uvot/image/*.gz
[gs66-iniesta:~/TALKS/iPTF2013] scenko% gunzip 00032850003/xrt/event/*.gz
```

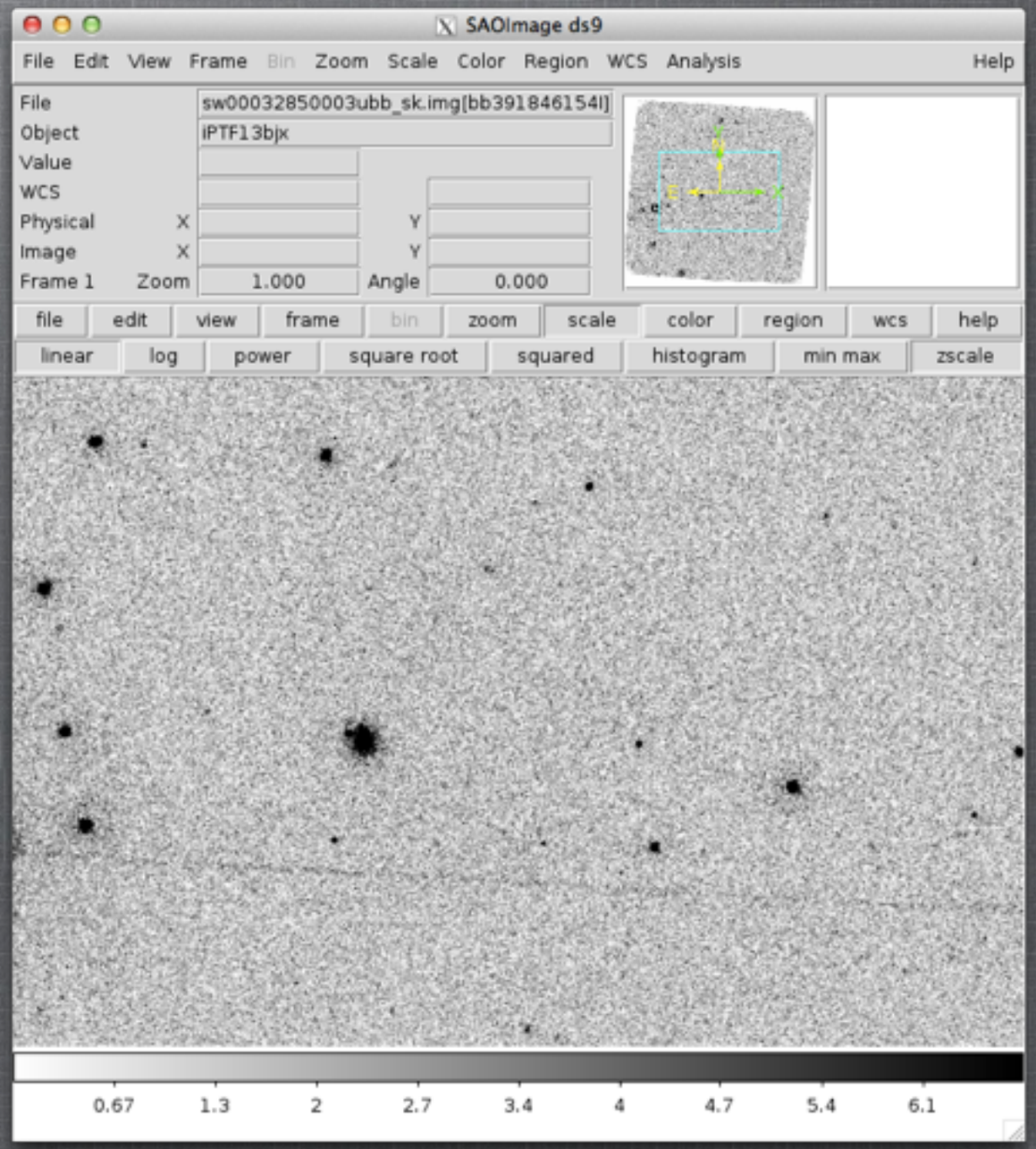
- 6 multi-extension FITS files from UVOT (one per filter)
- 2 cleaned event files from XRT

UVOT MEFS

2. tcsh

```
[gs66-iniesta:~/TALKS/iPTF2013] scenko% cd 00032850003/uvot/image/
[gs66-iniesta:00032850003/uvot/image] scenko% pyhead -p object,filter,date-obs,exposure *.img
# File[ext]    object  filter  date-obs  exposure
sw00032850003ubb_sk.img    iPTF13bjx  B  2013-06-02T06:09:11  n.a.
sw00032850003ubb_sk.img[1]    iPTF13bjx  B  2013-06-02T06:09:11  100.17342532
sw00032850003ubb_sk.img[2]    iPTF13bjx  B  2013-06-02T17:31:49  56.857236703
sw00032850003ubb_sk.img[3]    iPTF13bjx  B  2013-06-02T19:02:47  45.0536069538
sw00032850003um2_sk.img    iPTF13bjx  UVM2  2013-06-02T06:19:36  n.a.
sw00032850003um2_sk.img[1]    iPTF13bjx  UVM2  2013-06-02T06:19:36  316.808599626
sw00032850003um2_sk.img[2]    iPTF13bjx  UVM2  2013-06-02T17:37:50  184.080219486
sw00032850003um2_sk.img[3]    iPTF13bjx  UVM2  2013-06-02T19:07:38  137.560644323
sw00032850003uuu_sk.img    iPTF13bjx  U  2013-06-02T06:07:24  n.a.
sw00032850003uuu_sk.img[1]    iPTF13bjx  U  2013-06-02T06:07:24  100.173425379
sw00032850003uuu_sk.img[2]    iPTF13bjx  U  2013-06-02T17:30:46  56.8681222054
sw00032850003uuu_sk.img[3]    iPTF13bjx  U  2013-06-02T19:01:57  45.0427410454
sw00032850003uvv_sk.img    iPTF13bjx  V  2013-06-02T06:17:50  n.a.
sw00032850003uvv_sk.img[1]    iPTF13bjx  V  2013-06-02T06:17:50  100.162579182
sw00032850003uvv_sk.img[2]    iPTF13bjx  V  2013-06-02T17:36:49  56.8681025528
sw00032850003uvv_sk.img[3]    iPTF13bjx  V  2013-06-02T19:06:48  45.0536070125
sw00032850003uw1_sk.img    iPTF13bjx  UVW1  2013-06-02T06:03:57  n.a.
sw00032850003uw1_sk.img[1]    iPTF13bjx  UVW1  2013-06-02T06:03:57  199.56499972
sw00032850003uw1_sk.img[2]    iPTF13bjx  UVW1  2013-06-02T17:28:46  113.942518975
sw00032850003uw1_sk.img[3]    iPTF13bjx  UVW1  2013-06-02T19:00:21  90.324393627
sw00032850003uw2_sk.img    iPTF13bjx  UVW2  2013-06-02T06:10:58  n.a.
sw00032850003uw2_sk.img[1]    iPTF13bjx  UVW2  2013-06-02T06:10:58  400.357056055
sw00032850003uw2_sk.img[2]    iPTF13bjx  UVW2  2013-06-02T17:32:52  228.123949486
sw00032850003uw2_sk.img[3]    iPTF13bjx  UVW2  2013-06-02T19:03:39  181.85415165
```

Each MEF has 3 separate exposures.
Want to combine these into a single frame (to increase SNR).



UVOTIMSUM

```
2. tcsh
[gs66-iniesta:00032850003/uvot/image] scenko% heainit
[gs66-iniesta:00032850003/uvot/image] scenko% uvotimsum
Name of input image file(s)[sw00032850003ubb_sk.img] sw00032850003ubb_sk.img
Output file name[B.fits] B.fits
```

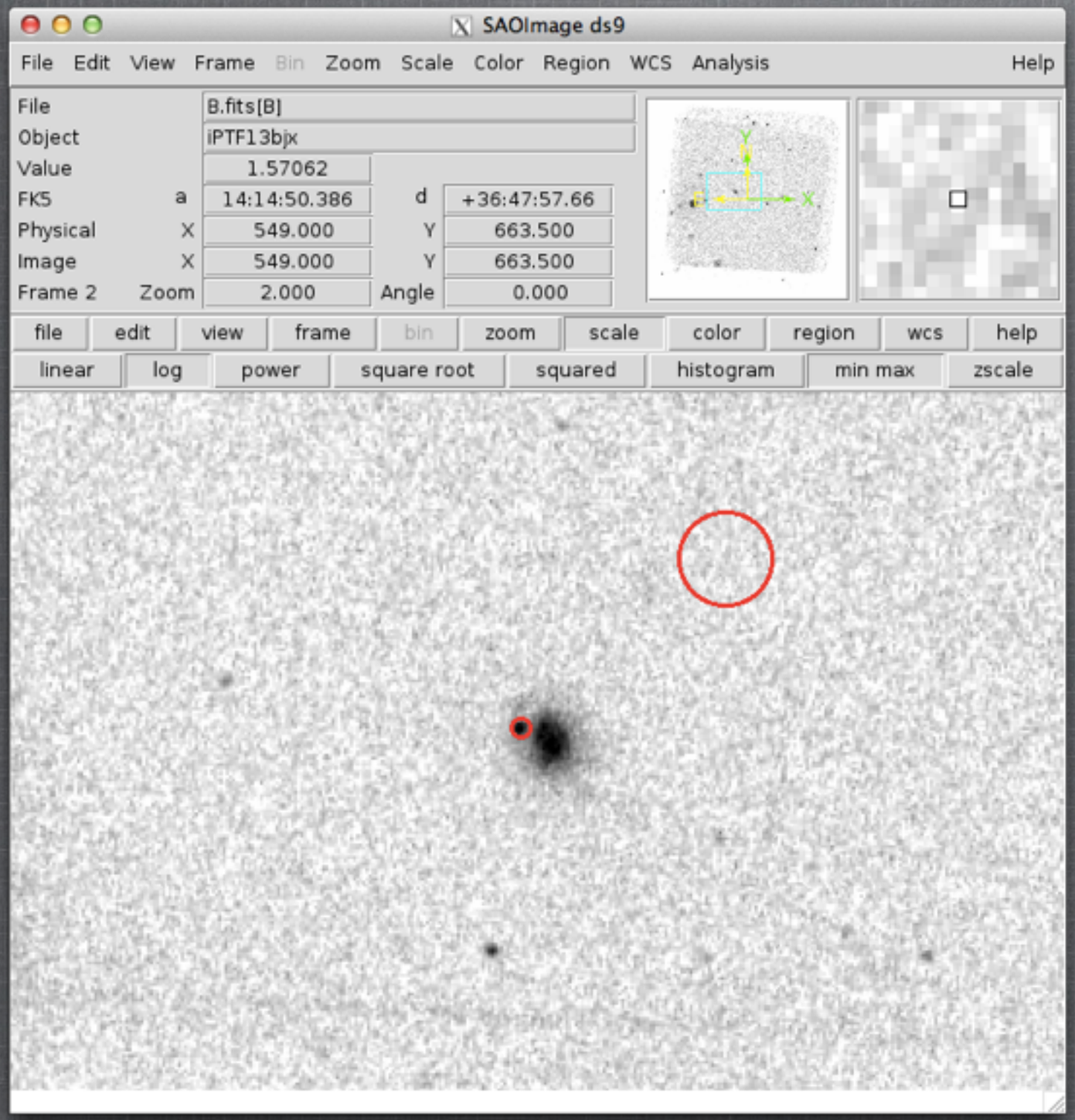
Parameters

Table 3.14.2 lists the input parameters for UVOTIMSUM. Parantheses indicate parameters that are not compulsory. If these parameters are not specified on the command line, the tool will look-up the current value in the parameter file. Users can inspect the parameter file by typing plist uvotimsum.

Table 3.14.2: Parameter descriptions for UVOTIMSUM.

Parameter	Description
Infile	Input FITS image file containing a series of image extensions
outfile	Output FITS image with a single image extension
method	Image rebinning method. Options are GRID or XIMAGE
(pixsize)	Pixel size for the output image. The default (or if pixsize=0) is to rebin the input images to match the coarsest image in the series. Units are degrees
(cleanup)	UVOTIMSUM creates a number of intermediate files in your working directory. These are only useful for software developers. This option removes all intermediate files at the end of the routine. The default is yes
(clobber)	Should UVOTIMSIM overwrite a file with the same name as the output? The default is no
(history)	Should UVOTIMSIM write HISTORY keywords to the output file? This creates a record of the processing performed on the file. The default is yes
(chatter)	Verbosity of the tool (0-5). This parameter control how chatty the tool is (0 = quiet. 5 = noisy)

GENERATE REGION FILES



src.reg:
fk5;circle(14:14:52.11,+36:47:28.6,3")

back.reg:
fk5;circle(14:14:46.58,+36:48:23.3,15")

5″ is the standard UVOT aperture (i.e., what the photometric system is defined for). 3″ generally works better for faint sources or those in high background regions. We will correct for this shortly.

UVOTSOURCE

2. tcsh

```
[gs66-iniesta:00032850003/uvot/image] scenko% uvotsource image=B.fits srcreg=src
.reg bkgreg=back.reg sigma=3.0 outfile=B.out syserr=yes output=ALL apercorr=CURV
EOFGROWTH chatter=0
uvotsource: warning: applyLargeScaleSensitivity: unknown detector position
uvotsource: Source
            Position: RA = 14h 14m 52.11s, Dec = +36d 47m 28.6s (J2000)
            Position: RA = 213.71712, Dec = 36.79128 (J2000)
            Exposure: 202.08 s
              Filter: B
        Significance: 22.6 sigma (stat)
    Background-limit: 3.0 sigma (stat)
uvotsource: UVOT b magnitude (Vega system)
              Source: 17.75 +/- 0.06 (stat) +/- 0.02 (sys)
          Background: 23.56 arcsec^-2
    Background-limit: 21.01
   Coincidence-limit: 12.68
uvotsource: UVOT b magnitude (AB system)
              Source: 17.63 +/- 0.06 (stat) +/- 0.02 (sys)
          Background: 23.44 arcsec^-2
    Background-limit: 20.89
   Coincidence-limit: 12.56
uvotsource: Flux density [erg/s/cm^2/A]
              Source: 5.17 +/- 0.29 (stat) +/- 0.02 (sys) x 10^-16
          Background: 2.45 +/- 0.05 (stat) +/- 0.01 (sys) x 10^-18 arcsec^-2
    Background-limit: 2.56 x 10^-17
   Coincidence-limit: 5.48 x 10^-14
uvotsource: Corrected rate [count/s]
              Source: 3.514 +/- 0.200 (stat)
          Background: 0.017 arcsec^-2
    Background-limit: 0.174
   Coincidence-limit: 372.234
uvotsource: Raw rate [count/s]
              Source: 2.860 +/- 0.126 (stat)
          Background: 0.017 arcsec^-2
    Background-limit: 0.168
   Coincidence-limit: 90.644
uvotsource: Flux density [mJy at 6.925 x 10^14 Hz]
              Source: 3.23 +/- 0.18 (stat) +/- 0.01 (sys) x 10^-1
          Background: 1.53 +/- 0.03 (stat) +/- 0.01 (sys) x 10^-3 arcsec^-2
    Background-limit: 1.60 x 10^-2
```

- Under the hood, *uvotsource* does:
  - Add counts in source region
  - Subtract counts from background region
  - Correct for coincidence loss
  - Correct for different aperture (bright stars)
  - Apply flight-determined calibrations to convert counts to magnitude, flux, etc.

UVOT NOTES

- Beware trailed images, bad astrometry, etc.
- If you want photometry for all individual exposures, try *uvotmaghist*
- For background subtraction, perform *exactly the same commands* on your reference image, then subtract *coincidence-corrected count rates* (and convert those to magnitudes manually)

XRT REDUCTION

2. ximage

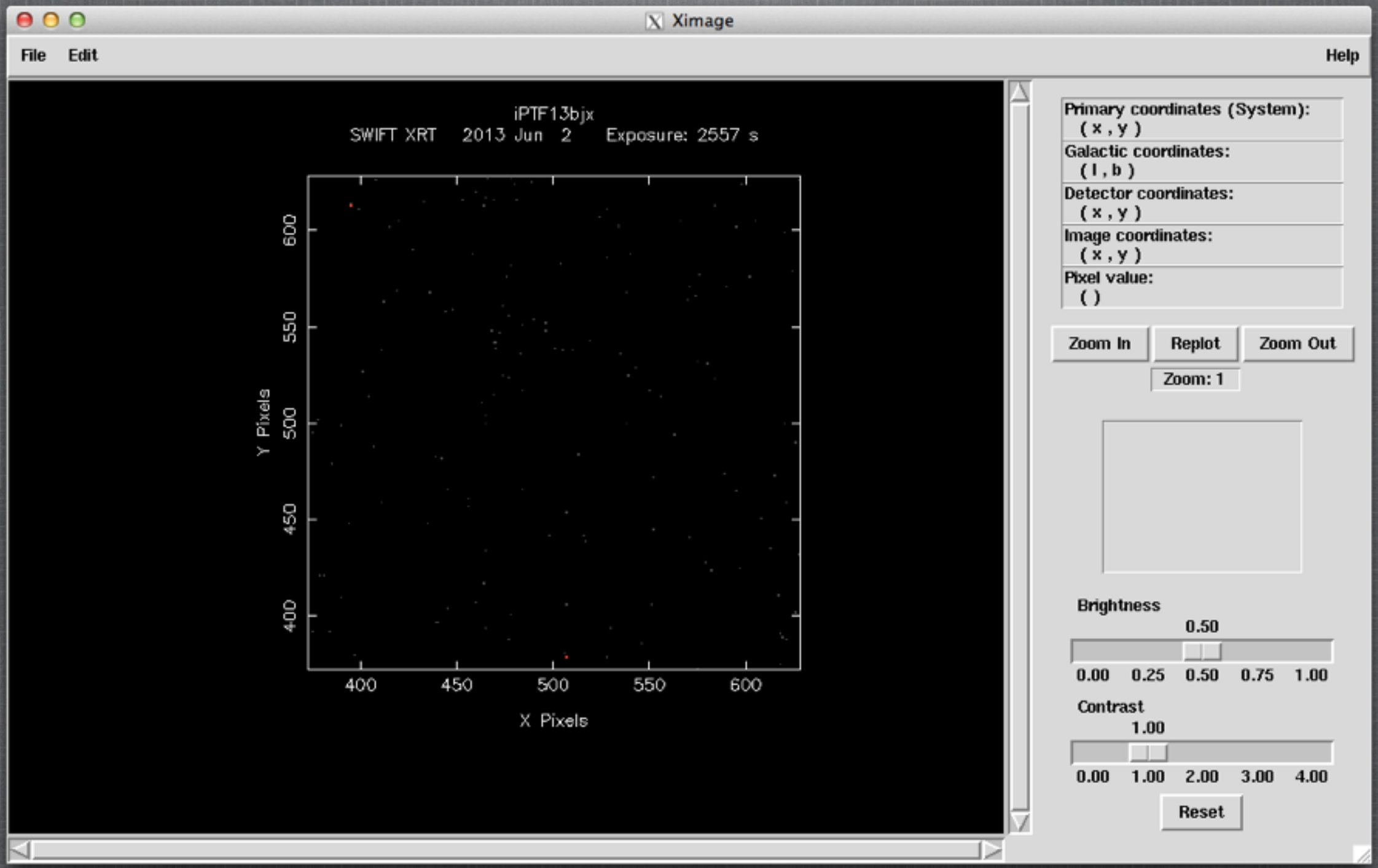
```
[gs66-iniesta:00032850003/xrt/event] scenko% ls
sw00032850003xpcw3po_cl.evt     sw00032850003xwtw2st_cl.evt
sw00032850003xwtw2sl_cl.evt
[gs66-iniesta:00032850003/xrt/event] scenko% ximage
******************************************************************************
*                              Welcome to XIMAGE                             *
******************************************************************************

                                                          Type "help" for help


                                                VERSION 4.5.1  22:36:33 07-Aug-2013

 No of detectors read in:   30
[XIMAGE> read sw00032850003xpcw3po_cl.evt
 Telescope SWIFT XRT
 Image size = 256 x 256 pixels
 Image rebin = 1.000
 Image center = 500.5, 500.5
 Using gti for exposure 2557.44600004 s
 Reading an events file
 File contains        663 events
 Accepted: 149 Rejected: 514
  Image level, min = 0.0000000 max = 2.0000000
 Map: MAP1 Keyword: mapcopy = MAP1 MAP9
 Map: MAP9 Keyword: mapcopy = MAP1 MAP9
 Copied MAP1 to MAP9
[XIMAGE> cpd /xtk
[XIMAGE> disp
 Plotting image
  Min = 0.  Max =  2.
```

XRT REDUCTION



XRT SOURCE DETECTION

2. ximage

ximage | Python

```
[XIMAGE> detect/snr=3
 Calculating background: Poisson statistics assumed
 Too many (>80%) background boxes rejected
 8   failed
 Too many (>80%) background boxes rejected
 16   failed
 32 0.002704327
 64 0.0022735596
 >>> Optimum box size =  64
 Background box size =  64
 Background =2.2736E-03 cts/original-pixel
            =2.2736E-03 cts/image-pixel
            =5.7593E-04 cts/sqarcmin/s
            =8.8900E-07 cts/original-pixel/s
 Source box size (orig pix):    8 (image pix):    8
 >>>>> Searching for excesses
      6 excesses found
 >>>>> Removing contiguous sources
 Using fast contiguous search
          2 excesses left
 >>>>> Sort by radius
 >>>>> Applying thresholds
  Using average energy for PSF:  1.
  snr threshold =  3.
  bgnd fluctuation probability limit =  0.0001
 >>>>> removing duplicates
 No sources detected
```

XRT BETTER LIMITS

2. ximage

ximage | Python

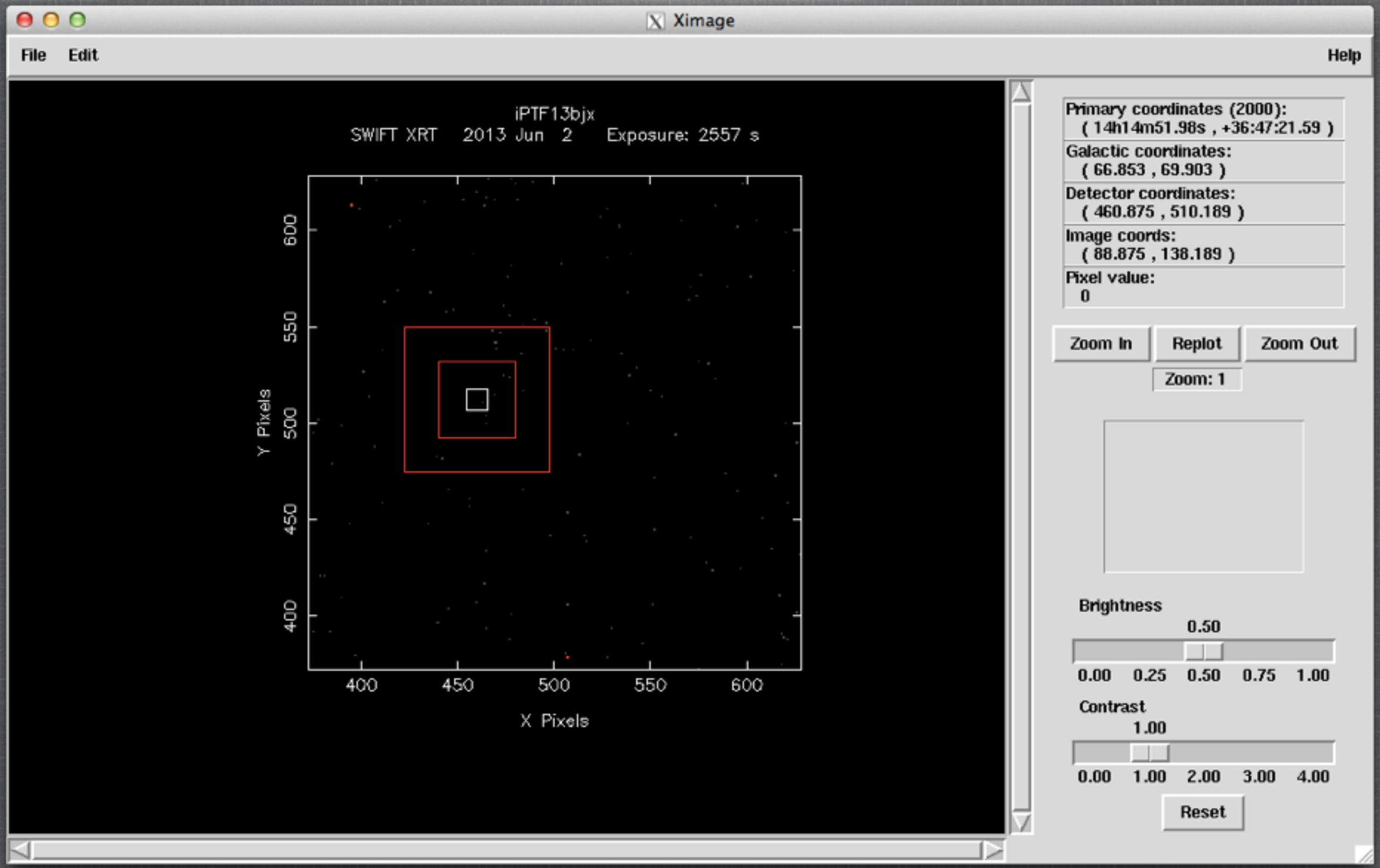
```
[XIMAGE> sosta
 Using MAP1
 Using a locally computed background
 Select the center of source box (Right button exits)
 Current map set to MAP1
 Plotting image
  Min = 0.  Max =  2.
 Current map set to MAP1
 Set to 16 levels
 Current map set to MAP1
 Plotting image
  Min = 0.  Max =  2.
 Current map set to MAP1
 Set to 16 levels
                    X = 460.19135    Y = 512.23560
  Using average energy for PSF:  1.
 Source half-box for 0.64 EEF is    5.3 pixels
        Half-box for 0.90 EEF is   18.6 pixels
 Total # of counts 1.0000000 (in 121 elemental sq pixels)
 Background inner radius:   19.6 pixels; outer radius:   37.3 pixels
 Innerbox counts 6.0000000 in 1521 sq or pixels
 Outerbox counts 16.000000 in 5625 sq or pixels
 Background counts 10.000000 in 4104 sq pixels
 Background/elemental sq pixel :                2.437E-03 +/- 7.7E-04
 Background/elemental sq pixel/sec :            9.528E-07 +/- 3.0E-07

 Source counts :                                7.052E-01 +/- 1.0E+00
 s.c. corrected for PSF :                       1.234E+00 +/- 1.8E+00
 s.c. corrected for PSF + sampling dead time
                               + vignetting     1.240E+00 +/- 1.8E+00
 Source intensity :                             2.757E-04 +/- 3.9E-04 c/sec
 s.i. corrected for PSF                         4.824E-04 +/- 6.9E-04 c/sec
 s.i. corrected for PSF + sampling dead time
                               + vignetting -> 4.849E-04 +/- 6.9E-04 c/sec <-
 Signal to Noise Ratio             :            7.021E-01
                                                 Poisson    Gauss
 Pr. that source is a fluctuation of back. :    2.55E-01   9.70E-02


    Exposure time                 :       2557.446 s
    Vignetting correction         :      1.005
    Sampling dead time correction :      1.000
    PSF correction                :      1.749

      Three sigma upper limit : 5.92E-03 cts/s
    Optimum half box size is      : 5.5000000 orig pixels
[XIMAGE>
```

XRT BETTER LIMITS



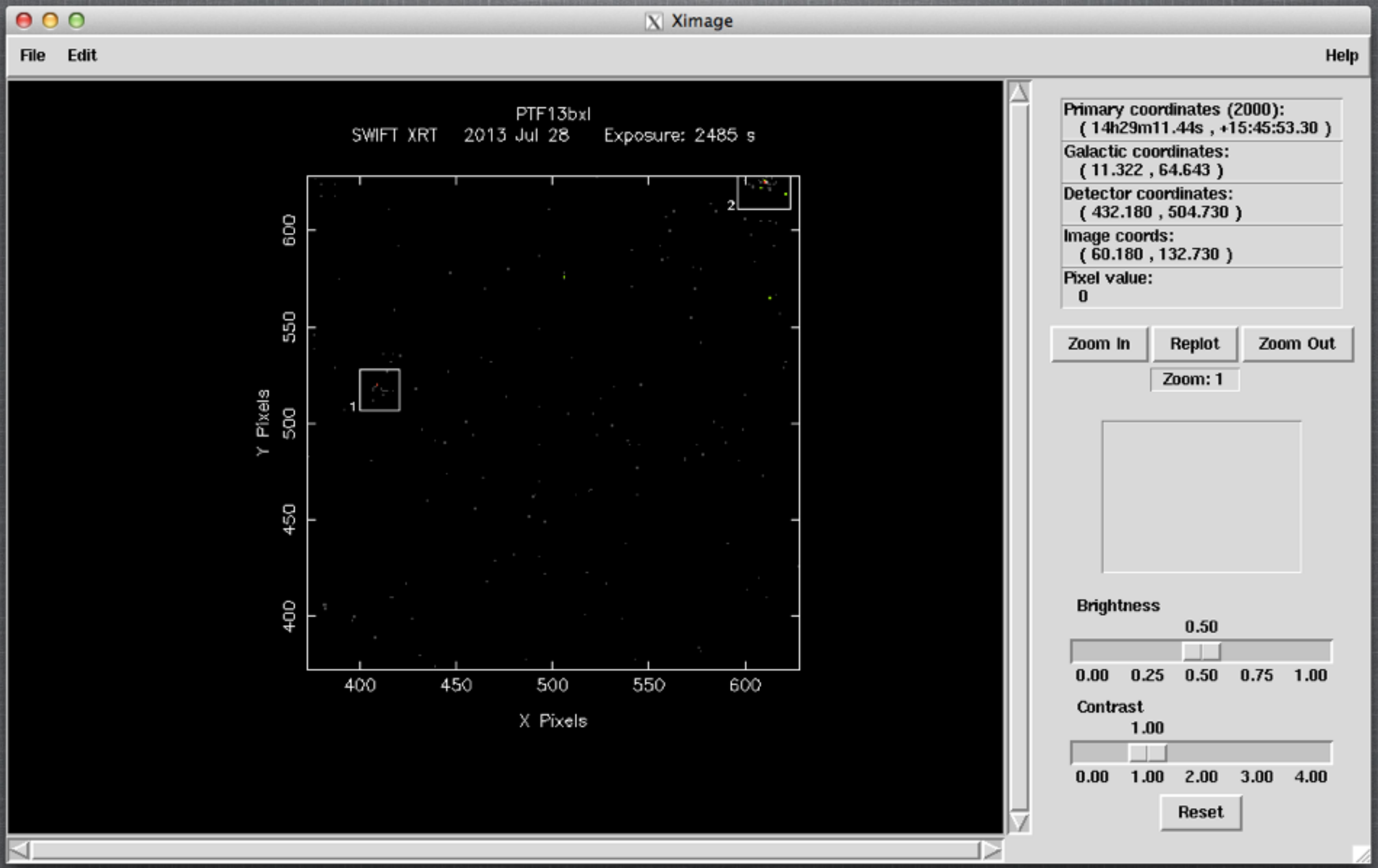
AN ACTUAL DETECTION

2. ximage

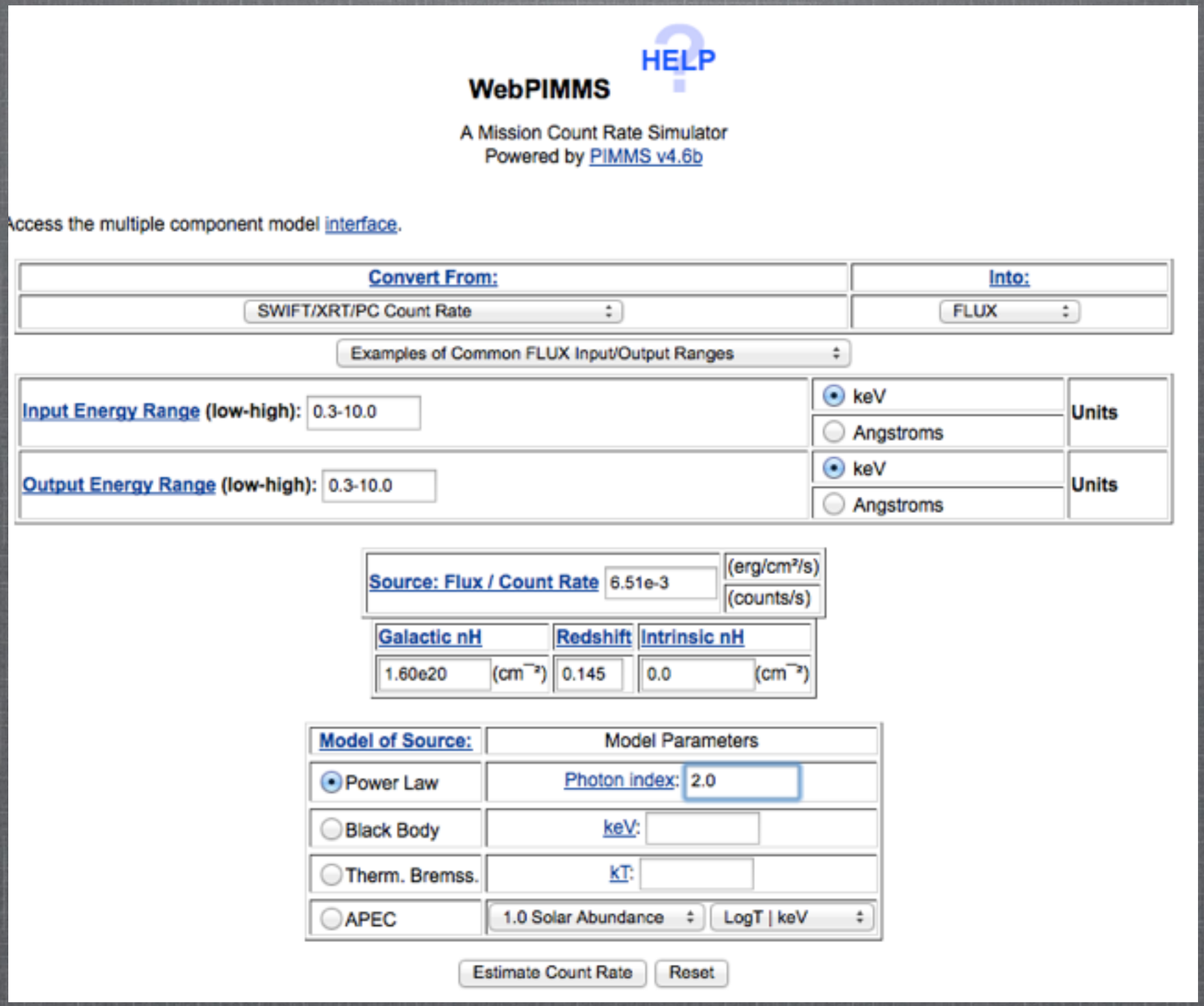
ximage | Python

```
[XIMAGE> detect/snr=3
 Calculating background: Poisson statistics assumed
 Too many (>80%) background boxes rejected
 8   failed
 Too many (>80%) background boxes rejected
 16   failed
 32 0.0030088683
 64 0.0022135417
 >>> Optimum box size =  64
 Background box size =  64
 Background =2.2135E-03 cts/original-pixel
            =2.2135E-03 cts/image-pixel
            =5.7713E-04 cts/sqarcmin/s
            =8.9086E-07 cts/original-pixel/s
 Source box size (orig pix):    8 (image pix):    8
 >>>>> Searching for excesses
     75 excesses found
 >>>>> Removing contiguous sources
 Using fast contiguous search
          5 excesses left
 >>>>> Sort by radius
 >>>>> Applying thresholds
  Using average energy for PSF:  1.
  snr threshold =  3.
  bgnd fluctuation probability limit =  0.0001
 >>>>> removing duplicates
   #   count/s    err         pixel      Vig  RA(2000)   Dec(2000)   Err  H-Box
                             x     y     corr                         rad  (sec)
    1 6.51E-03+/-1.9E-03   410.4   517.5 1.03 14 29 15.0 +15 46 23.2  -1     25
    2 1.74E-02+/-3.0E-03   609.7   624.6 1.09 14 28 42.4 +15 50 35.8  -1     32
[XIMAGE>
[XIMAGE>
```

AN ACTUAL DETECTION

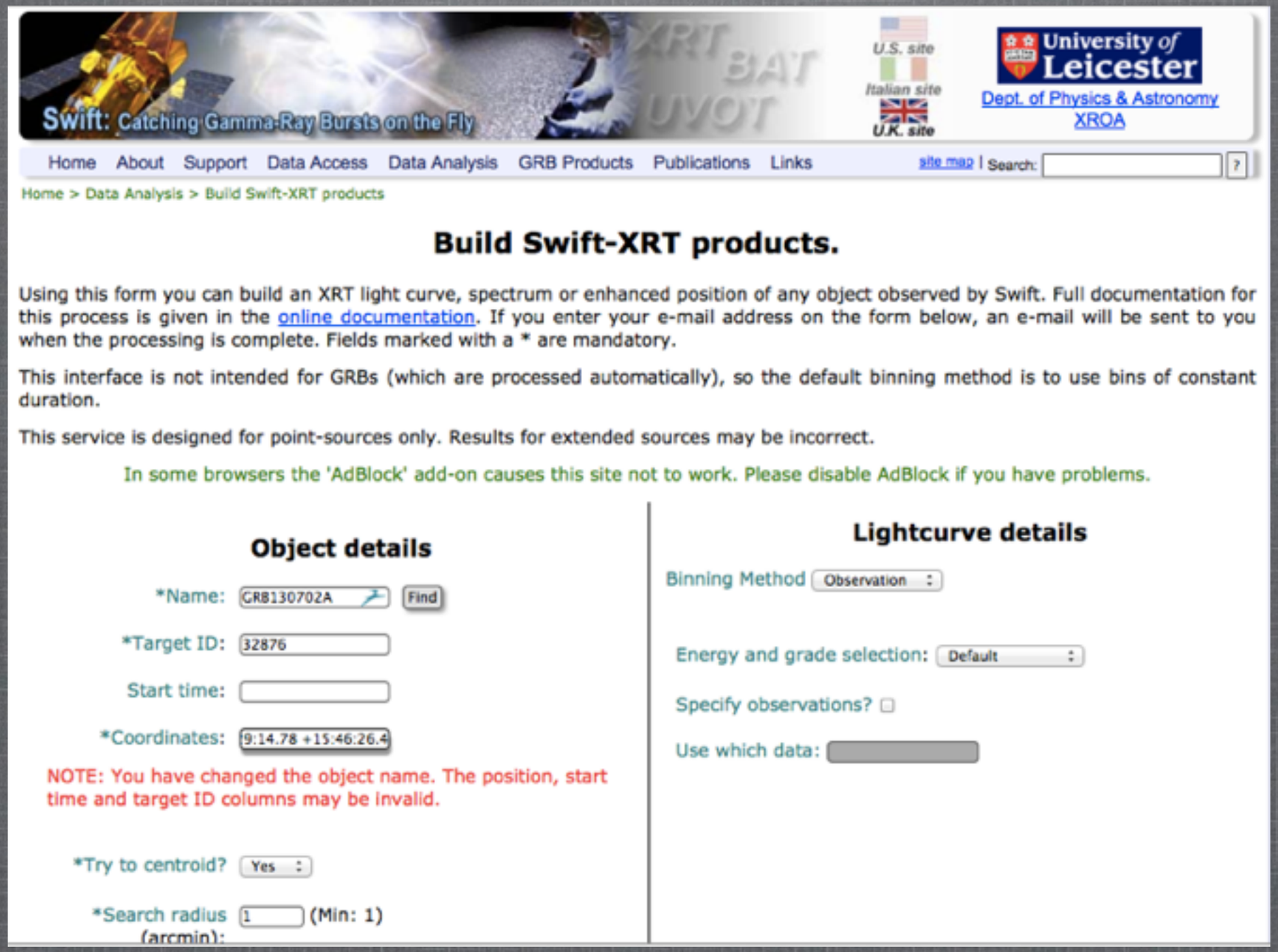


FLUX CONVERSION



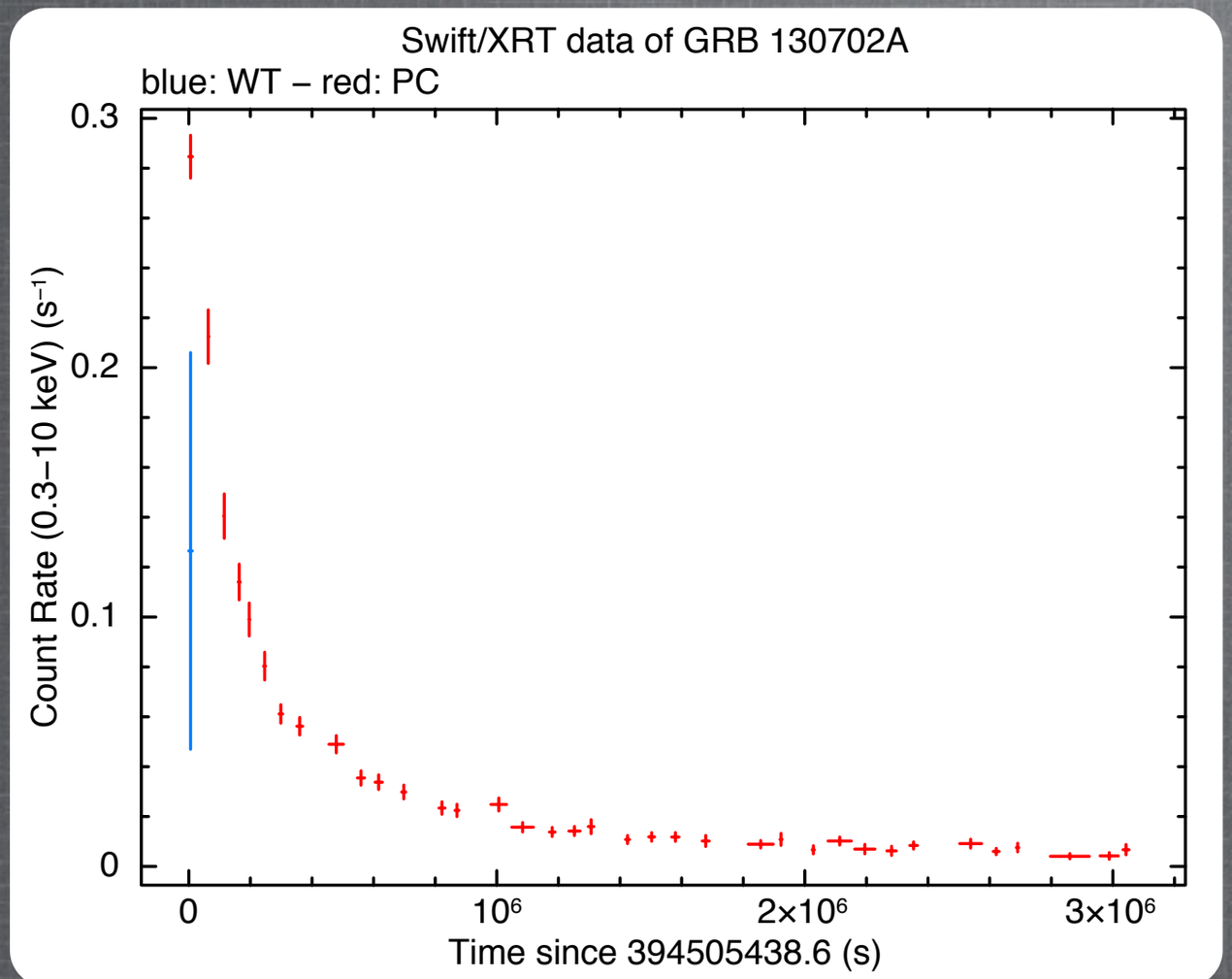
http://heasarc.nasa.gov/Tools/w3pimms.html

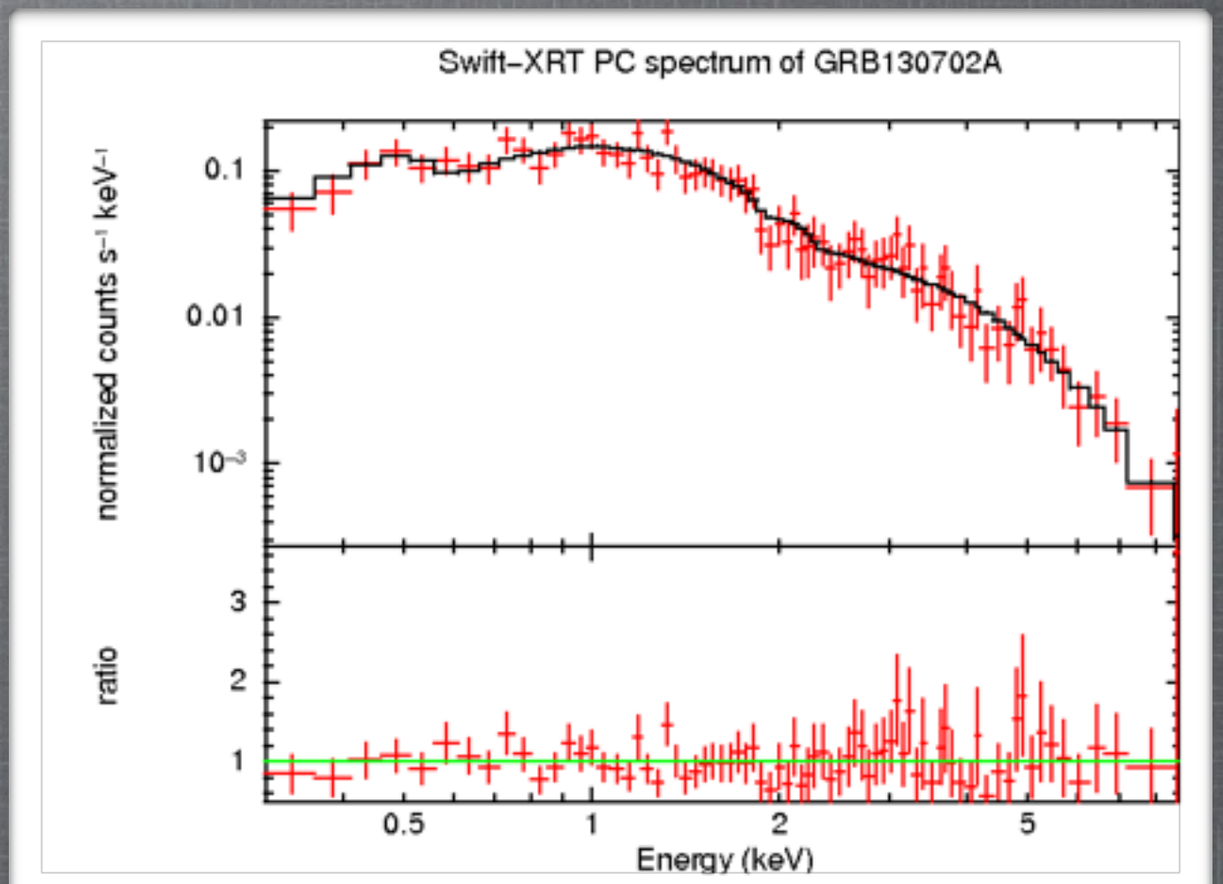
AUTOMATED XRT ANALYSIS



http://www.swift.ac.uk/user_objects

AUTOMATED XRT ANALYSIS





Only applicable when source detected (i.e., don't use for upper limit measurements).